TOWARD A NEW GENERATION OF CONSTRUCTION MANAGEMENT SOFTWARE

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ABSTRACT

Most of projects are managed using commercial software. Despite their usefulness, software's based on traditional planning modeling present many weaknesses. We can note that their graphical planning concept is still global and require a detailed scheduling in order to calculate the critical path. Also, they lacked to answer to all planners' needs, to solve all kind of problems or to represent all types of projects. This paper proposes a new generation of construction management software. This system is arranged in independent modules that can be connected to the project database. Modules are systems intended to execute the different functions, such as estimation or planning. The paper discusses in detail the graphical planning module. This module is design based on the Chronographical Theory, which can present the information under different and compatible facets in order to help manager to solve various problems, to represent different types of projects and to allow the decision-maker to analyse the schedule according to his/her level of responsibility in the project. The proposed system has also a project database that can be fully or partially connected to the lots, sub-contractors or company database. Data can then be completely or partially shared. The proposed system tries to overtake the existing weaknesses associated to the commercials software's.

KEY WORDS

Planning, Scheduling, Chronograph, Software, Integrated System, Manage By Objective (MBO), Gantt, Precedence, Construction Project.

1. Introduction

The project management for construction is characterized by the variability of the execution conditions, the changing in the project emplacement and the instability for the constitution of teams and crews. Thus, only a limited quantity of data can be accumulated and stored, and the work is then performed often, based on the personal experience of the managerial team. These particularities distinguish this sector from others domains of activities, in particular the industrial sector, in which the information is easily capitalized and the activities of research & development are well established.

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Moreover, the process of completion of construction projects passes through several phases[3] that implicate many specialties[4] in order to execute various projects type[5] covered by many kind of contract[6] that engaged many intervening[7] and involved many functions[8] and activities[9] to be carried. Each phase, process or function posses its own properties and than should be managed differently.

Management software should be adapted to this reality. This paper, analyzes the fundamentals concepts on which a new generation of construction management software should be based. This analysis study in detail the Graphical Scheduling Module, based on the chronographical modeling theory.

2. Existing commercial project management software

A great majority of project are managed using commercial project management software[10]. Software assist and help to mange the project, accommodates and facilitates the project administration, make easier the data communication and propose several features and analyses. Most of them are able to:

- Define phases using summary and expanded tasks and hierarchies activities through breakdown structures;
- Show Gantt Diagram, logical networks (CPM & Precedence diagrams) and calculate the critical path.
- Plan activities in different units from hours to years, schedule durations, permit activities splitting and stretching and use different calendar for each task or resource.
- Show predecessor constraints and logical dependencies between activities (FS, SS, FF & SF types with lead or lag) on bar chart or via a precedence diagram. Manage costs, assign and allocate resource to the activities and optimize the resources utilization and levelling.
- Sort and filter data, reports tabular information and some graphical presentation as resources histogram and S-curves
- Manage multi project; permit web-based coordination and posses integrated project management system that include many tools.

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[3] Starting from the idea of project, going through the feasibility studies, conception, engineering & design, preliminary and detailed drawings & specs, tenders & procurement process, construction to the Finalizing of work Start up

[4] As architectural, civil, structure, mechanical, electrical, equipments, process engineering, instrumentation, etc.

[5] Like civil works, industrial, commercial, municipal and residential, etc.

[6] Based on Hourly rate, lump sum, administration contract, construction management, turnkey, etc.

[7] As owners, promoters, architects, consultants, contractors, public or private organization, associations, ministries, citizens, etc.

[8], Quality, time, cost, risk and human resources management, etc.

[9]As scope definition, communication, validation, approval and work acceptation, optimization of process, claims investigation etc.

10 Artemis 7, by Artemis International Solutions Corp.; Asta Powerproject, by Asta Development plc; Discover UDA, by UDA Technologies Inc.; eTaskMaker, by InterPlan Systems Inc.; iCPM, by HeadsUp Technologies, LLC; Microsoft Office Project, by Microsoft Corp; Open Plan, by Welcom; Primavera Project Planner and SureTrak, by Primavera Systems, Inc.

In addition *Asta Powerproject* employs some feature also proposed by the chronographic modeling. This software is able to draw multiple tasks on the same row, such as different floors of a building and can also do more than one link between two tasks.

In spite of this, many weaknesses are still associated with these project management software. We can remark that the proposed graphical schedule is global, so the entire project is presented on one sheet as one entity and not with independent lots that can be managed separately. The planner should, from the beginning of the project, detail all the activities in order to calculate the critical path. They also don't always take in consideration that each department, team or sub contractor has to manage its own activities within some objective of budget, duration and milestones in order to realize a certain deliverables. Because of that, these systems do not use multiple sheets, like spreadsheets, to mange the lots separately. They also do not use multiple layers, as CAD, in order put data and constraint on different layer and help manager to improve the graphical visualizations of the schedule.

Time scaled schedules are mostly bar chart diagrams. It is easy to notice that the number of activities presented with this type of modeling is not proportional with the presentation area, from where emerge a non-optimal uses of the work plan. The time-scaled networks do not show always the regrouping of the activities in sub-networks. For that, it is difficult to read the dependences lines, which are often very dense, cutting between themselves and crossings the activities lines. Consequently, doing project scheduling on a computer screen becomes a complex task (Pinnell 1980; Mason 1984; Fisk 2003; Francis 2004).

None of these software's are intended to plan all type of project (e.g. linear project). Furthermore, they are only directed by activities and cannot show graphical the resources constraints or those of working area or to present the production schedule. The activities are regarded as one entity and support only external relationships constraints. The internal decompositions as a function of quantity are not available. Thus, the internal execution constraint and the follow-up cannot be shown accurately. The margins suggested analyze the activities like only one entity ignoring all the internal process. In addition, an incorrect use of delays is often associated with the relationships, which in return can produce wrong answers and prevent an accurate self-adaptation of the network.

Many others weaknesses exist concerning functions, such as cost analyses, earned value and performance index calculation, or graphical reporting. These weaknesses are not discussed in this paper. These shortcomings have an influence specifically on the quality of the planning and on the project management in general and often, an unrealistic schedule is produced. The effort devoted to the manual adjustments is considerable. In conclusion, the graphical schedule representation seems to be underdeveloped. In order to foster and propose improvements for this field, we put forward this study.

3. Integrated system

3.1. Standardisation versus variability

With project complexity and variability, it almost impossible to fix from the beginning, the whole scope of specifications and processes. A project is managed in independent phases in order to employ an appropriate process for each discipline or step. Many management systems are used for such purposes[11]. The major problem seems to be the lack of compatibility between these systems, which increase the complexity of the management process. The data transfer becomes a costly task. For example the cost transferring between the final estimation and scheduling becomes a huge task if the two functions are using a different coding or structure.

The objective of the standardization is to design a complete system, an integrated management tool that could include virtually all the processes. The information should be centralized, for all the project life cycle, to insure a unique data recording, the ease of information sharing and communication and to improve the facility of information transfer between the different management functions. This consistency in the process of management should be benefit for decision making while saving time**.**

3.2. Design of the integrated system

The projected project management system is based on an integrated approach that favours information sharing between different phases and functions. This integrity should not affect the flexibility and the adaptability of the system to the reality.

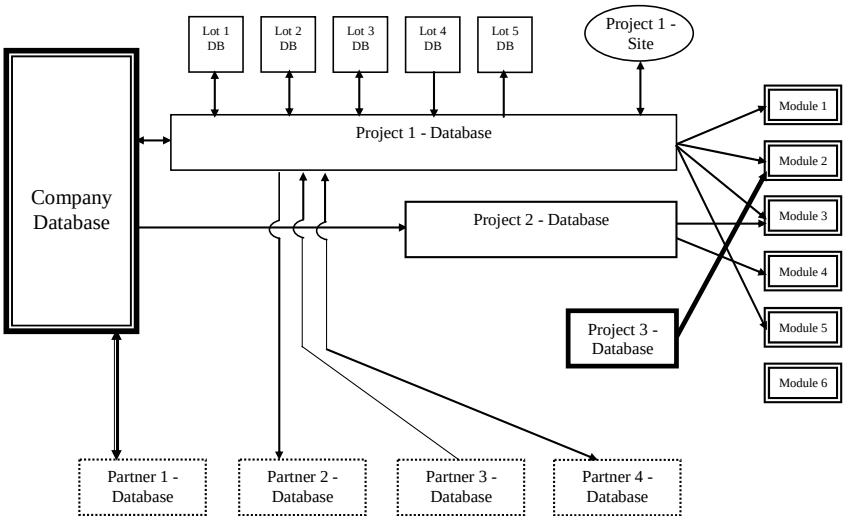
In order to respond to these needs, the system is arranged in independent modules that can be connected to the project database. Modules are systems intended to execute the different functions, such as estimation or planning. One can then integrate one or more modules to his project database.

In addition, project database can be fully or partially connected to the lots, sub-contractors or company database. These connections can be unidirectional, which means to read or to write only into data base or two-directional, read and write. Thus, data can then be completely or partially shared. The figure 1 shows this concept.

Thus, *Project 3* is shown as one entity completely unconnected to databases. It also uses only one module (module 2). This method permits full flexibility of data integration into the project. However, no data is shared with any other entity or with the database. Furthermore, *Project 1* uses many modules to respond to different functions. *Project 1* is also divided in many lots that can be managed independently. Each lot possesses its own database.

[11] Compatibility, billing & invoicing, economical, financial & profitability analysis, banking, attendance sheet & payment slip, engineering and design, environmental management, planning, costs and scheduling following, risk analysis, etc.

figure 1. Integrated system



These databases are partially or fully connected to the project database. Lots can be managed by the project manager or by others entities, like sub-contractors. Project database is also connected to the company's or to some others partner's database. This methodology requires a good collaboration and discipline from all the parties, but on the other hand, it allows:

- An integrated management system functionality, for instance, the directly allocate the employees working hours from their time sheet to the project activities, to plan a meeting or to assign an activity to a certain resources, knowing their availabilities.

- Knowledge accumulation in the centralized database, and take advantage from the existing database and knowledge systems, such as the utilisation of the estimating data accumulated by other projects in order to estimate the time and cost of the project activities.

Each project management team should have the choice to define the degree of integrity of the project to the different databases, but also between the different functions of the project. Module should also be flexible, that could arrange data to correspond to the manager needs and to represent different situations.

This paper analyses the scheduling approach of the Graphical Planning Module based on the chronographical modeling theory. New researches could be carried out for the others modules.

4. The Graphical Planning Module

4.1. Discussion

4.1.1 Several Methods or Diverse Facets of a Single Modeling

The actual situation of project scheduling reveals that traditional methods seem to be unable, individually, to answer to all the planners' needs, to solve all their problems or to adapt to all types of projects. Each of them possesses its advantages and inconveniences. For scheduling and cost control, and resources allocation and levelling, it is important to view a time-scaled modeling. So, the use of Gantt diagram becomes indispensable. For presenting logical interdependency between activities, critical path networks utilization becomes obvious. For linear projects, employment of Line of Balance or one of its variants are more adapted. Other methods can be also used, such as PERT to manage uncertain duration, GERT to manage variable sequences and simulation models to optimize production.

Furthermore, managers have to deal with various types of projects and they are confronted to all sorts of problems. To answer to these various needs, managers have to handle information within several and incomplete methods, which are incompatible between each other's. The existence of several scheduling methods is criticized because of lack of compatibility; the existence of a universal model, which can present information on different and compatible facets, is considered as an optimal solution. This strategy is also coherent with an objective of the standardization of the project-planning domain.

4.1.2 Current situation of the Graphical Modeling

The utilization of tabular planning is widespread for scheduling and controlling construction projects. Planning through a traditional graphical model is still considered to be a fairly complex task for most of project managers. In spite of the usefulness of the tabular planning, one must not neglect the importance of graphical modeling in the decision-making process.

Currently, the projects are more complex and involve many specialties. During the planning process several scenarios and modifications are proposed. The scheduling method is chosen according to its ease for handling modifications. This characteristic is not certainly the one that applies for timed-scaled planning manual methods. A logical diagram, like non Time-Scaled Network, is usually used. The software prepares a Gantt or Precedence Diagram using the input data. Some software can convert this schedule to a time-scaled network. So far, users cannot prepare time-scaled networks directly on screen. Besides, the results require a special visual capacity to be able to comprehend them. The manual planning is required to make major modifications, because the computed resulting networks are, usually, difficult to manipulate. Knowing that the changes are very frequent, the scheduling process becomes a complicated task that generates important preparation time and costs. For that purpose, the current process is considered as rigid.

Project management commercial software's are also unable to represent many traditional model, such as the linear, probabilistic and generalized or simulations methods. These

limitations discourage most of the small and middle size companies to adopt a wide utilization of the feature associated with the project management software's.

4.2. Planning Module Design

Users need a planning which shows to them what they want to know in a form that is easy to assimilate. In order to meet this objective, existing schedules should improve the following: the accuracy and fidelity of representation of the project planning; and the enhancement of the visual quality and clarity of the graphical modeling. A model can have a good visual representation but shows a limited quantity of information. On the other hand, a model can be very accurate for the project but with a dreadful visual clarity.

Fidelity of representation

Trying to represent project planning through a single detailed traditional schedule is considered as a complicated and hazardous task. That means the planner could not, from the beginning of the project, detail all the project activities. Planning is considered a process in progress, in which information grows continuously. The solution is to divide the project into manageable phases and lots that could be planned independently, but connect to a project database. Each entity (department, team or sub contractor) is able to manage its own lots within its budget, duration and milestones. To be more accuracy, the activities can feature decompositions as a function of quantity or internal execution constraints. The internal and external relations can be constraints of durations or production. User can also assign more than one link between two tasks.

In order to response to this reality, the Planning Module systems use multiple sheets and sub sheets, in order to mange the lots separately. Manager has to define, on a summary sheet, the major deliverables. He has to define their budgets and milestones and perform the control. Detailed tasks and activities should be planned progressively by the concerned entities on separately sheets for which the objectives are imposed.

Visual Clarity

The graphical presentation of most of the commercial software', using traditional scheduling methods is questionable. The limitations are, for instance, the non-optimal utilization of the graphical scheduling presentation area, the complexity of following the scheduling constraints on screen, the adaptation of the used model to all types of project and the utilization of activity as the only entity to present the production-scheduling tool.

In order to solve these problems and make the system more user-friendly, the Planning Module systems based on the chorographical modeling theory (Francis et Miresco 2000, 2002a, 2002b, 2005; Francis 2004) present the information on different and compatible facets capable to help manager to solve various problems, to represent different types of projects and to allow the decision-maker to analyze the schedule according to his/her level of responsibility in the project. Many constraints can then symbolize the productions tools.

Module uses multiple layers to put data and constraints on a different stratum. The activities, and others constraints, are arrangement on these layers according to the users needs in order to help manager to improve the graphical visualizations of the schedule.

User Interface

Next figures show few samples of displays of the proposed integrated management system. The interface shows that the project is associates with many modules. Each module is presents by one or more sheets, the name of each sheet appearing on the lowest Tabs (*Estimation, Lots, Analyses and Graph, etc.*). The Graphical Planning Module is presented by four (4) sheets: *Summary, Recapitulative, Lots* and *Analyses*:

1. The Summary sheet identifies the data that should be entirely controlled by the project manager. This sheet can also have one or more sub-sheet in order to divide the project into phases, steps, etc. In these sheets, the manager defines the structure, the principal deliverables, the milestones, the budget and all the other constraints.

2. The recapitulative sheet describes in detail the whole project consolidated in a single sheet as a result of the detailed Lots, describe in Lots sheets.

3. The Lots sheet can also be composed by many sub-sheets (more levels are allowed) that define the different lots. In the next figures we can view the upper tab, which indicates the different lots (from *Concrete* to the *Process Mechanics Works*). Each lot represent the detail of one deliverable shown in the Summary sheet and contain the activities or the sub deliverables that should be done.

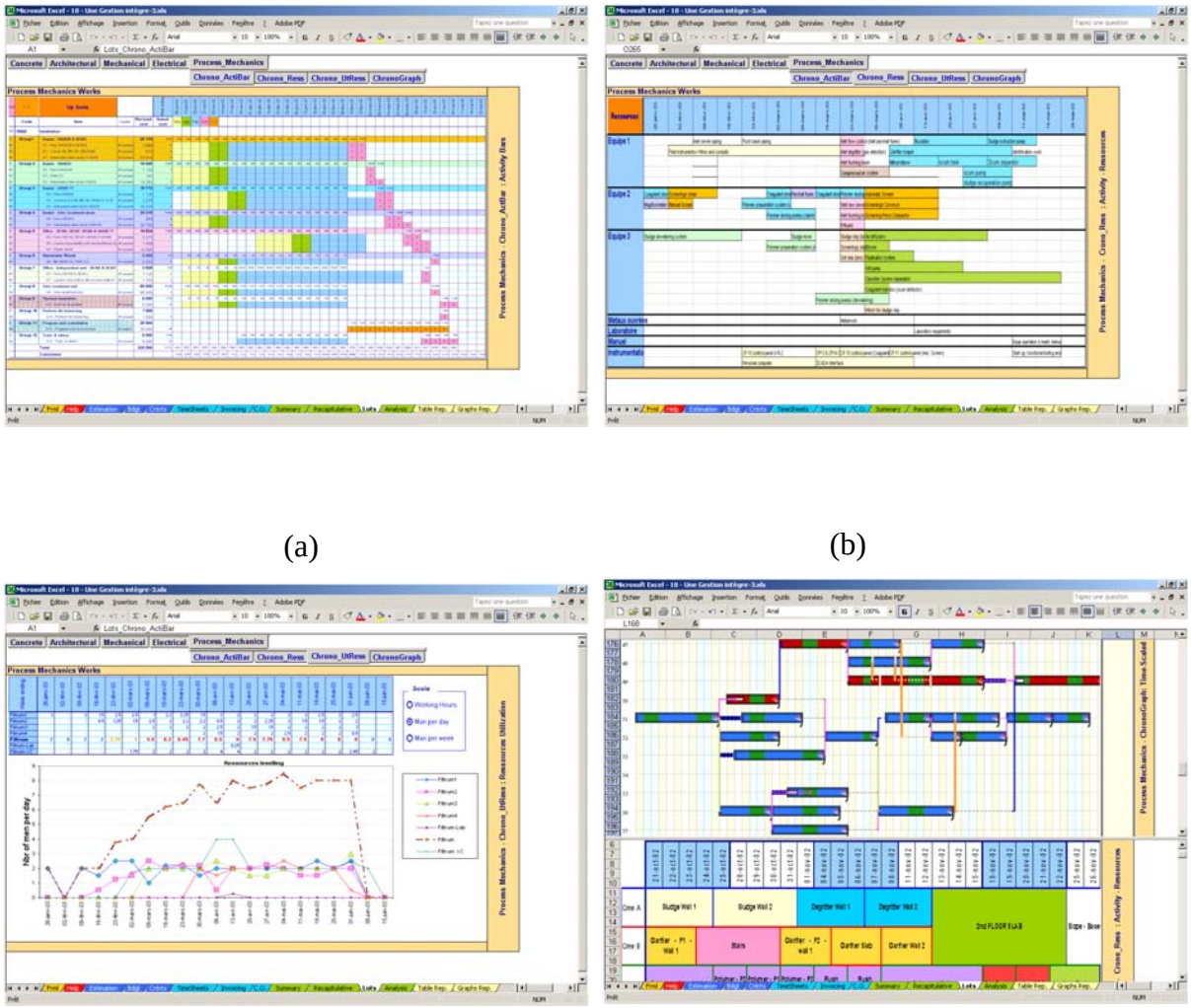
   Graphical Planning Module shows on different facets several approaches to schedule the same data. The sub-upper tab, (*Chrono-ActiBar* to *ChronoGraph*), represents these facets as a different way to schedule the *Process Mechanics Works*.

4. The Analyses sheets, represents additional sheets that allow the manager to perform many analyses without affecting the original scheduling. One can isolate a certain number of activities, resources; constraints, etc. collected from one or many sheets, in order to perform several analyses. Transferring these data onto original schedule should be an option, if the resulting analyses appear acceptable.

Figures 2.a, 2.b and 2.c are demonstrating three different compatible facets for the process mechanics lots. The advantage of this feature is to view information on different way in order to help manager to solve various problems.

In Figure 2.d, the screen is split in two sections that show the chronograph facet of the *Process Mechanics* lot in the upper side; and the Chrono_Ress facet for the concrete lots in the lower side. The manager can than view more than one lots on the screen in order to coordinate many lots together by adding relations and constraints between their respective activities.

figure 2. Different Facet for view the schedule of the *Process Mechanics* lot.



(a) (b)

(c) (d)

Conclusion

The proposed system tries to overtake the existing weaknesses associated to the commercials software's. The system is arranged as independent flexible modules, which can be integrated to the project database. This concept favours the information sharing between different phases and functions and allows the scheduling presentation under different and compatible facets. These features can help manager to solve various problems, to represent different types of projects and to analyse the schedule according to his/her level of responsibility in the project.

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